AIR TURBINE FOR COMBUSTION ENGINE

Related Applications

[0001] This application claims priority to United States Patent Application No. 10/077,324 filed February 15, 2002 and entitled "Air Turbine for Combustion Engine," and which is hereby incorporated by reference.

Technical Field

[0002] The present invention relates to air turbine devices suitable for use in the intake or exhaust of a combustion engine.

Brief Description of the Drawings

[0003] FIG. 1 is a cross-sectional side view of a first embodiment of an air turbine device in accordance with the present invention;

[0004] FIG. 2 is a cross-sectional end view of an induction chamber of FIG. 1;

[0005] FIG. 3 is an end view of an airfoil of FIG. 1;

[0006] FIG. 4 is an end view of a vortex ring of FIG. 1;

[0007] FIG. 5 is a cross-sectional side view of the air turbine device of FIG. 1 illustrating the flow of air or gases through the device;

[0008] FIG. 6 is another cross-sectional side view of the air turbine device of FIG. 1 illustrating the flow of air or gases from the induction chamber into the expansion chamber;

[0009] FIG. 7 is a cross-sectional side view of a second embodiment of an air turbine device in accordance with the present invention attached to an exhaust system of a combustion engine;

[0010] FIG. 8 is a cross-sectional side view of a third embodiment of an air turbine device in accordance with the present invention attached to an exhaust system of a combustion engine;

[0011] FIG. 9 is a cross-sectional side view of a fourth embodiment of an air turbine device in accordance with the present invention;

[0012] FIG. 10 is a cross-sectional side view of another embodiment of an air turbine device in accordance with the present invention;

[0013] FIG. 11 is a cross-sectional end view of an expansion chamber housing an airfoil supported by a plurality of blades in accordance with the present invention;

[0014] FIG. 12 is a cross-sectional side view of an alternative embodiment of an air turbine device in accordance with the present invention;

[0015] FIG. 13 is a cross-sectional side view of an alternative embodiment of an air turbine device in accordance with the present invention; and

[0016] FIG. 14 is a cross-sectional side view of an alternative embodiment of an air turbine device in accordance with the present invention.

Detailed Description of Preferred Embodiments

[0017] Referring to the drawings wherein like numerals indicate like elements throughout, there is shown in FIG. 1 an air turbine device, generally indicated at 10, in accordance with an embodiment of the present invention. The air turbine device 10 is comprised of an outer housing 12 having a generally cylindrical shape. The housing 12 defines an inlet port 14 and an outlet port 16. It should be noted that while the housing 12 has a cylindrical shape, those of skill in the art will appreciate

that other geometrical shapes may be feasible. An inlet tube 18 is secured to the inlet port 14 for attachment of the air turbine device 10 to an exhaust system of a vehicle (not shown). The inlet tube 18 is provided with a pair of vortex rings 19 and 21 to help form a vortexial flow of air through the air turbine device 10. The housing 12 defines an expansion chamber 20 which extends from the inlet 14 to the outlet 16.

[0018] Housed within the housing 12 is an induction tube 22 which is fixedly mounted to the outlet 16 of the housing 12. The induction tube 22 is comprised of an elongate tubular member having a plurality of perforations 24 formed therein. In the preferred embodiment, the perforations 24 are louvers which extend into the induction chamber 30 formed by the tube 22. The louvers are formed by stamping or cutting the exterior wall 32 of the tube 22 to force portions 34 of the wall 32 into the interior of the tube 22. As shown in FIG. 2, the louvers 36 are preferably formed in a helical pattern around the tube 22. It is also contemplated that one or more spiral or helical slits may be provided in the tube 22 to accomplish a similar effect. Thus, the terms louvers or perforations are intended to include such structure.

[0019] Referring again to FIG. 1, the louvers 36 extend around the interior surface 38 of the tube 22 and face in a direction so as to encourage air flowing toward the outlet 40 of the tube to flow from the tube 22 into the expansion chamber 20. A pair of vortex rings 42 and 44 are secured within the tube 22 proximate the outlet 40 of the tube 22. The vortex rings 42 and 44 provide a slight amount of back pressure to the air turbine device, which is sometimes necessary to the operation of some gas engines. In addition, the vortex rings help to maintain the vortexial flow of air as the air leaves the outlet 40.

[0020] Attached to the inlet 46 of the tube 22 is a disc-shaped member 50 which extends across the expansion chamber proximate the inlet 14 of the housing 12. The disc-shaped member 50 forms an airfoil in the path of the air flowing through the housing 12. This airfoil 22 defines a central aperture 52 which is in fluid communication with the inner vortex chamber 30. In addition, the airfoil 22 has a diameter that is less than the diameter defined by the inner surface 54 of the housing 12. As such, air entering the inlet tube 18 can either flow through the aperture 52 or through the annular space 56 formed between the airfoil 50 and the inner surface 54 of the housing 12.

[0021] FIG. 3 illustrates a front view of the airfoil 50 shown in FIG. 1. The airfoil 50 is provided with the circular aperture 52 which is concentric with the airfoil 50. The size of the airfoil 50 as well as the diameter of the aperture 52 is dependent upon the flow of air from the exhaust of the combustion engine. The size of the vortex expansion chamber, however, is dependent upon the diameter of the inlet coupled thereto. The diameter of the expansion chamber is defined by 1.5 times the inlet pipe diameter. The length of the expansion chamber to accommodate the second harmonic resonance is 2.0 times the diameter of the expansion chamber. The length of the expansion chamber to accommodate the third harmonic resonance is 3.5 times the diameter of the expansion chamber. For a six inch expansion chamber diameter, the outermost airfoil diameter is approximately 5.4 inches and the diameter of the aperture or bore of the airfoil is approximately 1.6 inches. In order to create the desired vortex effect and mixing the air flows passing around and through the airfoil, the area of the annular space between the airfoil and the expansion chamber and the area of the aperture are sized to produce the most efficient flow of air through the device. In proportion, the ratio of air passing around the airfoil

compared to the air passing through the airfoil for a six inch diameter expansion chamber is approximately 2.7 to 1.

[0022] FIG. 4 illustrates a vortex ring, such as vortex ring 19 shown in FIG. 1. Similar to the dimensions of the airfoil 50, the size of the vortex ring 19 is dependent upon the inner diameter of the inlet tube 18 to which the vortex ring 19 is attached. The vortex ring 19 extends into the inlet tube to form a slight constriction but not enough to cause any appreciable restriction of flow therethrough. Obviously, as shown in FIG. 1, the outer diameter of the vortex ring 19 is defined by and thus equal to the inner diameter of the inlet tube 18.

[0023] Referring now to FIG. 5, the flow of exhaust 60 through the air turbine device 10 is illustrated. As the flow of exhaust 60 enters the expansion chamber 20, the air is directed either through 62 or around 64 and 66 the airfoil 50. The air passing around the airfoil 50 will necessarily be at a higher velocity than the air 62 that flows directly through the aperture 52. The faster moving air 64 and 66 will create a low pressure zone within the outer vortex or expansion chamber 20.

[0024] The air 62 entering the inner vortex or induction chamber 30 will be at a lower velocity than the air in the expansion chamber 20 and thus at a higher pressure. As such, the air 71 within the induction chamber 30 will be encouraged to flow into the expansion chamber 20. As shown in FIG. 6, the flow of air 70 from the induction chamber 30 to the expansion chamber 20 is further assisted or encouraged by the louvers 36 formed in the tube 22.

[0025] Referring again to FIG. 5, the arrangement of the louvers 36 force the air 70 into a vortexial flow 72 around the tube 22. As this flow 72 reenters the inner tube 22 in order to pass out through the exit or exhaust port 79 as represented by arrow

80, the inner flow 71 of air is also encouraged into a vortexial flow. As such, both the flow of air around the tube 22 and inside the tube 22 is flowing in a vortexial manner.

[0026] FIG. 7 illustrates another embodiment of a tunable air turbine device, generally indicated at 100, which includes the air turbine device 10 shown in FIG. 1. The air turbine device 10 has an opening 102 formed in the housing to which a tunning chamber 104, preferably comprised of an elongate tube, is attached. The tuning chamber 104 forms a second flow passage from the air turbine device 10 but is linked to and in fluid communication with the expansion chamber 20. The tuning chamber 104 reconnects and is in fluid communication with an exhaust port 106 attached to the exit port 40 of the air turbine device 10.

[0027] The amount of air 110 flowing through the tuning chamber 104 is controlled by a valve 112, preferably an electronically controllable butterfly valve, which can partially or totally restrict the flow of air 110 through the tuning chamber 104. The butter fly valve 112 may be powered by a 12 volt power supply 114 and include a variably controllable open position gauge 116 and/or an open/close controller 118. The resonant sound emanating through the tuning chamber 104 will have had a lesser amount of high frequency noise cancelled by the air turbine device. By controlling the amount of flow 110 through the tuning chamber 104, a user can effectively control the tone of the sound from the air turbine device system 100.

[0028] As shown in FIG. 8, another preferred embodiment of an air turbine device, generally indicated at 200, is adapted for use in marine applications. An air turbine device 202 having a configuration similar to that illustrated in FIG. 1 is attached to an exhaust manifold 204. The exhaust flow diverter 204 includes an exhaust inlet 206 which is coupled to the exhaust manifold (not shown) of an inboard

boat motor. An actuator 208 controls a valve 210 housed within the exhaust flow diverter 204. The valve 210 is preferably a butterfly valve which can partially or totally obstruct the air flow into the air turbine device 202, as controlled by a user. Similar to the butterfly valve illustrated with respect to FIG. 7, the butterfly valve 210 may be powered by a 12 volt power supply 212 and include a variably controllable open position gauge 216 and/or an open/close controller 218. The air that is restricted by the butterfly valve 210 is diverted into the diverter outlet 220. The diverter outlet is coupled to the factory stern drive outlet (i.e., the exhaust outlet already existing on the marine vessel).

[0029] The exhaust flow diverter 204 is thus controllable to allow a portion or all of the exhaust air flow entering the exhaust inlet of the diverter to flow through the air turbine device 202. As such, the outlet 222 of the diverter 204 is coupled to the inlet 224 of the air turbine device. The outlet 226 of the air turbine device 202 is coupled or mounted to the hull 228 of the boat or marine vessel. The outlet 226 is positioned above the water line 230 so that, unlike the factory exhaust which uses the water to act as an air turbine device, the flow of exhaust out of the air turbine device 202 is not impeded by the back pressure that would otherwise be caused if the outlet 226 of the air turbine device 202 was submerged. Such a free flowing air turbine device configuration increases horse power while providing a compact air turbine device that does not add significant weight or size to an existing vessel.

[0030] FIG. 9 illustrates another embodiment of an air turbine device, generally indicated at 300 in accordance with the principles of the present invention. Similar to other embodiments described herein, the air turbine 300 is comprised of an inlet 302, an expansion chamber outer housing 304 and an outlet 306. The inlet 302 and outlet 306 are of similar diameter, with the housing 304 having a larger diameter and

interposed between the inlet and the outlet. A chop core 308 is positioned within expansion chamber 316 and defines an induction chamber 310. The chop core 308 is provided with a plurality of louvers 312 that extend into the induction chamber 310 and are arranged along the inner wall 314 of the chop core 308 so as to encourage rotational flow of the air or exhaust gases entering the induction chamber out into the annular expansion chamber 316 defined between chop core 308 and the expansion chamber outer housing 304. Thus, the louvers may be spirally or helically configured around the chop core 308.

[0031] An airfoil 318 is positioned in the proximal end 320 of the housing 304 and is attached to the proximal end 322 of the chop core 308. The airfoil 318 has a frustoconical shape with a curved outer surface 320 and a longitudinally extending central bore 322 extending from the proximal end 324 of the airfoil 318 to the distal end 326 and in fluid communication with the induction chamber 310. The airfoil 318 may be comprised of a ceramic material, metal or other heat resistant materials. The air foil 318 divides the air entering the device 300 through the input 302 so that a portion of the air enters the induction chamber 310 through the bore 322 while the remaining air flow enters the induction chamber 310 from the expansion chamber 316.

[0032] An aspect of the invention is to cause the air flow through the device to rotate into a vortex. The spinning air causes the air to flow more efficiently through the device 300. The air flow is first caused to rotate relative to the device 310 at the intake 302 by a pair of vortex convolutions 328 and 330 that are formed into the intake portion 302 of the device 300. The vortex convolutions 328 and 330 are each formed by bending, casting or otherwise forming the intake 302 to form annular recesses 331, 332 and 333 in order to form the interior annular recesses or

convolutions 328 and 330. As the air flow encounters the convolutions 328 and 330 passes through the convolutions, the air is caused to spin. The air continues to spin as it passes over and around the airfoil 318. The perforations or louvers 312 are configured to cause rotation of the air flow counter to the rotation caused by the convolutions 330, 328 as the air is drawn by the convolutions from the induction chamber to the expansion chamber 316 through the louvers 312. This mixing of the air flow in the expansion chamber and induction chamber causes turbulence in the air flow. The result of such turbulence is a cancellation of noise otherwise present in the exhaust flow.

[0033] This turbulent flow then recombines in the outlet 306 and is again caused to spin into a vortex as it passes through a second set of convolutions 336 and 338 formed in the outlet 306 in a similar manner to the convolutions 328 and 330 formed in the intake 302. Such a vortex at the outlet 306 again encourages the flow of air out of the device 300.

[0034] The length of the expansion chamber 304 also has an effect on the noise cancellation ability of the device 300. That is, the length of the device 300 can be tuned to cancel out various noise frequencies including multiple harmonics. That is, by tuning the length of the device 300 to match the frequencies generated by a particular engine, the first, second and third harmonics can be dampened producing a more quiet running engine.

[0035] Referring now to FIG. 10 another embodiment of an air turbine device, generally indicated at 400, is shown. The device is comprised of an intake 402, an expansion chamber housing 404 defining an expansion chamber 405 and an exhaust port 406.

[0036] Positioned within the expansion chamber 405 is an airfoil 408 that defines a longitudinally extending bore 412 and divides the air into a portion that flows around the air foil and a portion that flows through the air foil. A pair of airfoil convolutions 414 and 416 are provided in the bore 412 of the airfoil 408 to encourage vortex flow of the air through the airfoil and into the expansion chamber 405.

[0037] The airfoil 408 is concentrically centered within the expansion chamber 405 and held relative thereto with a plurality of vanes or blades 418 and 420. There may be two, three, four or more of the blades 418 and 420. The blades 418 and 420 as shown are configured to be spirally or helically oriented around the outer surface 422 of the airfoil 408 so as to cause rotation of the air flowing around the airfoil 408. The orientation of the blades 418 and 420 is such that the air flowing around the airfoil 408 is counter rotated to the air flowing through the bore 412. As the air recombines in the expansion chamber 405, counter spinning air flows cause turbulence therein between so as to cause cancellation of noise from the engine to produce a muffling effect while allowing essentially the free flow of exhaust gases through the device 400. The air then recombines in the expansion chamber 405 and exits through the exhaust port 406 with the convolutions 424 and 426 causing the air to spin in a vortex as it exits the device 400.

[0038] FIG. 11 shows a cross-sectional end view of an expansion chamber housing 500 with blades 501, 502, 503 and 504 supporting an airfoil cone 506. The blades 501 to 504 are attached to the inner surface 508 of the housing 500 and to the outer surface 510 of the airfoil cone 506 so as to cause rotation of the air flow passing around the airfoil cone 506 in the direction of the blades 501 to 504. It is desirable to orient the blades 501 to 504 so that the air flowing over the airfoil cone

510 is spinning in a direction opposite to the rotation of the air flowing through the internal passageway 512 extending through the airfoil cone 506.

[0039] Finally, as shown in FIG. 12, the principles of the present invention may be applied to the intake of a combustion engine as well. An intake air turbine 600 is comprised of an intake port 602, an expansion chamber housing 604 and an exhaust port 606. Housed within the expansion chamber housing 604 is an airfoil 608 that divides the air flow similar to that shown in the other embodiments herein. The intake port 602 is provided with vortex convolutions 610 and 612 that cause the air flow to rotate relative thereto. As an intake device, the flow of air from the intake port 602 to the exhaust port 606 is encouraged to rotate throughout the device. That is the air flowing through the expansion chamber, both around and through the bore 620 of the airfoil, is rotated in the same direction so as to increase the flow of air through the exhaust port 606 and into the intake manifold (not shown) of a combustion engine. The blades 616 and 618 that support the airfoil 608 within the housing 604 are helically oriented around the airfoil to encourage this consistent rotational flow of air around the airfoil so as to minimize turbulence as the air flow recombines in the expansion chamber 622. In the event of any such turbulence, the exhaust port vortex convolutions 624 and 626 encourage continued and uniform vortex rotation of the air flow.

[0040] Referring to FIG. 13, an alternative embodiment of an air turbine 700 is shown. As with previously described embodiments, the air turbine 700 includes an inlet 702, an expansion chamber housing 704 defining an expansion chamber 706, and an outlet 708. The expansion chamber 706 is in communication with the inlet 702 and the outlet 708. The inlet 702 and outlet 708 have a substantially similar diameter with the expansion chamber 706 having a diameter greater than the inlet

702 and outlet 708. An inlet tube 710 couples to the housing 704 and is aligned with the inlet 702. Likewise, an outlet tube 712 couples to the housing 704 and is aligned with the outlet 708.

[0041] A tube or chop core 714 is disposed within the expansion chamber 706 and defines an induction chamber 716 within. The tube 714 includes a plurality of perforations or louvers 718 that extend into the induction chamber 716. The perforations 718 are arranged along an inner wall 720 of the tube 714 so as to encourage rotational flow of the air or exhaust gases entering the induction chamber 716. The perforations 718 may be spirally or helically disposed around the tube 714.

[0042] The tube 714 includes a proximal end 722 having a tube input 724. The tube 714 divides passing gases so that a portion of the gases enter the induction chamber 716 through the tube input 724 while the remaining air flow enters the induction chamber 716 through the perforations 718. The separated air flow recombines in the induction chamber 716 and exits through the outlet 708. Thus, the tube 714 provides two air paths that are separated from an original incoming air flow and then recombined. The tube 714 may maintain a consistent diameter along its entire length. The tube 714 further includes a distal end 726 that is coupled to the outlet 708.

[0043] As in previous embodiments, the air turbine 700 may further include one or more inlet vortex convolutions 728, 730 disposed within the inlet tube 710. The vortex convolutions cause the air flow to rotate into a vortex. The spinning air causes the air to flow more efficiently through the device 700. The vortex convolutions 728, 730 are formed by bending, casting or otherwise forming the inlet 710 to form annular recesses 732, 734 in order to form the interior annular recesses or convolutions 728, 730. As the air flow encounters the convolutions 728, 730, the

air is caused to spin. The air continues to spin as it passes through and around the tube 714.

[0044] The outlet tube 712 may include outlet vortex convolutions 732, 734 that create a vortex in the passing air flow. The outlet vortex convolutions 732, 734 are disposed within the outlet tube 712 in a manner similar to the convolutions 724, 726 formed in the inlet tube 710. A vortex in the outlet tube 712 encourages the flow of air out of the air turbine 700.

[0045] Referring to Figure 14 an alternative embodiment of an air turbine 800 is shown similar to that illustrated in Figure 13. The tube 714 includes a converging portion 802 that is coupled to a main body 804 of the tube 714. The converging portion 802 provides decreasingly smaller diameters for the tube input 724. The converging portion 802 extends for a relatively small length compared to the entire tube length. The main body of the tube 714 has a diameter that remains substantially the same. The converging portion 802 encourages air flow through the tube input 718.

[0046] The embodiments illustrated in Figures 13 and 14 do not provide the same level of performance as previous embodiments incorporating airfoils. However, the air turbines 700, 800 provide improved performance over conventional devices and require relatively few components. It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.